US006113983A

United States Patent [19]

Zachariah et al.

[11] Patent Number: 6,113,983

[45] Date of Patent: Sep. 5, 2000

[54] **METHOD OF FORMING METALLIC AND CERAMIC THIN FILM STRUCTURES USING METAL HALIDES AND ALKALI METALS**

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[21] Appl. No.: **09/054,401**

[22] Filed: **Apr. 3, 1998**

Related U.S. Application Data

[60] Provisional application No. 60/041,965, Apr. 3, 1997, and provisional application No. 60/061,443, Oct. 9, 1997.

[51] **Int. Cl.**[7] **C23C 16/00**

[52] **U.S. Cl.** **427/253**; 427/250; 427/255.23; 427/255.28; 427/255.39; 427/255.391; 427/255.394

[58] **Field of Search** 427/250, 253, 427/255.23, 255.19, 255.28, 255.39, 255.394, 255.391, 314

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[57] **ABSTRACT**

A new low temperature method for nanostructured metal and ceramic thin film growth by chemical vapor deposition (CVD) involves the use of a low pressure co-flow diffusion flame reactor to react alkali metal vapor and metal halide vapor to deposit metal, alloy and ceramic films. The reaction chemistry is described by the following general equation:

$$(mn)\mathrm{Na}+n\mathrm{MX}_m \rightarrow (\mathrm{M})_n+(nm)\mathrm{NaX}$$

where Na is sodium, or another alkali metal (e.g., K, Rb, Cs), and MX_m is a metal-halide (M is a metal or other element such as Si, B or C; X is a halogen atom, e.g., chlorine, fluorine or the like; and m and n are integers). This reaction chemistry is a viable technique for thin film growth. In one mode, using the precursors of sodium metal vapor, titanium tetrachloride (the limiting reagent), and either argon or nitrogen gases, titanium (Ti), titanium nitride (TiN), titanium dioxide (TiO_2), and titanium silicide (TiSi, Ti_5Si_3, $TiSi_2$, Ti_5Si_4) thin films have been successfully grown on copper and silicon substrates. Conditions can be adjusted to prevent or minimize gas-phase particle nucleation and growth. Substrate temperatures can also be varied to prevent excessive salt deposition.

18 Claims, 13 Drawing Sheets